INGLE-SIDEBAN

THEORY

PART 1
and
PART 2

CNATT-M397 (Rev. 8-73) PAT

Naval Technical Training Command

1. Select the definition of each of the terms below. (1)

   a. Modulating (heterodyning).
   b. Amplitude modulation.
   c. Percentage of modulation.
   d. Modulation envelope.

2. Compute the frequencies transmitted from an a-m transmitter when an r-f carrier is modulated with specified audio frequencies. (2)

3. Select the definition of *upper sideband*. (5)

4. Compute the receiver bandwidth necessary to receive the output of an a-m transmitter. (7)

5. Compute the power contained in (a) the carrier and (b) the sidebands from the total average transmitted power of an a-m transmitter. (11)

6. Select the definition of *high-level modulation*. (14)

7. Select the definition of *low-level modulation*. (14)

8. Select the definition of *single-sideband transmission*. (24)

9. List three types of single-sideband transmissions. (25)

10. List four advantages of single-sideband communications as compared with a-m communications. (27)

11. Compute the receiver bandwidth necessary to receive the transmission of a single-sideband transmitter. (29)

12. Select the definition of *selective fading*. (37)

13. State why selective fading is held to a minimum when using single-sideband communications. (40)

NOTE: The number listed after each objective refers to the first frame teaching that objective.

SUGGESTED READING TIME 31 MINUTES

become imperative because of the tremendous amount of traffic in the high-frequency (3 to 30 MHz) spectrum and because present communications require faster, more reliable systems.

Single sideband (ssb) is not new. Over 50 years ago, it was determined that ONE sideband contains all the elements necessary to reproduce the original transmitted modulation signal (intelligence) at the receiver. During World War II, single-sideband systems were used extensively by the Armed Forces. At the present time, single-sideband systems are generally used for long-range, point-to-point communications systems.

Here are some terms and ideas that you need to know. Most of them should be familiar to you. Read the following definitions carefully and slowly.

a. MODULATING (HETERODYNING): These terms mean essentially the same thing: the combining of two frequencies across a nonlinear component. The result is that two new frequencies are produced in addition to the two original frequencies. These new frequencies are the sum and the difference frequency of the two original frequencies. The term MODULATION is generally used in connection with transmitters, and the term HETERODYNING is used in connection with receivers.

b. AMPLITUDE MODULATION: This is the process of combining an audio-modulating signal with an r-f carrier frequency. The outputs are the sum, the difference, and the two original frequencies. When viewed on an oscilloscope, the output appears as a

lating signal to the peak amplitude of the r-f carrier, expressed as a percentage. For example, if a 500-volt audio signal were used to modulate a 500-volt carrier signal, the PERCENTAGE OF MODULATION would be 100 percent.

d. MODULATION ENVELOPE: The modulation envelope is the outline of an amplitude-modulated wave. It resembles the shape of the audio-modulating wave and represents the intelligence to be transmitted.

Select the definition of each of the terms below.

_____ (1) Modulating (heterodyning).

_____ (2) Amplitude modulation.

_____ (3) Percentage of modulation.

_____ (4) Modulation envelope.

Definitions

a. The process of combining an audio-modulating signal with an r-f carrier frequency, which produces a waveshape whose amplitude varies according to the amplitude of the modulating

d. The combining of two frequencies across a nonlinear component, which results in the sum, the difference, and the two original frequencies.

2. When two frequencies are combined, as in modulation, the result is FOUR frequencies: the two original frequencies, the sum frequency, and the difference frequency.

For example: If a 1,000-kHz r-f carrier is modulated by a 3-kHz audio signal, the resultant frequencies will be

a. 1,000 kHz (r-f carrier),

b. 3 kHz (audio-modulating frequency),

c. 1,003 kHz (carrier plus the modulating frequency),

d. 997 kHz (carrier minus the modulating frequency).

These frequencies appear on a frequency spectrum, as shown below.

frequency, and the lower side frequency are transmitted. The audio-modulating frequency wil be lost as a discrete frequency, but will appear as amplitude variations in a composite view of the transmitted signal, such as an oscilloscope might provide.

What three frequencies will be transmitted from an a-m transmitter when a 1,500-kHz carrier is modulated by a 5-kHz audio signal?

Carrier--
1,500 kHz.

Upper frequency--
1,505 kHz.

Lower

3. In case the modulating signal is not a single t (as the 3-kHz signal), but rather a BAND of fre quencies (as in voice modulation), the sum and difference frequencies are bands of frequencies

the resultant frequencies will be

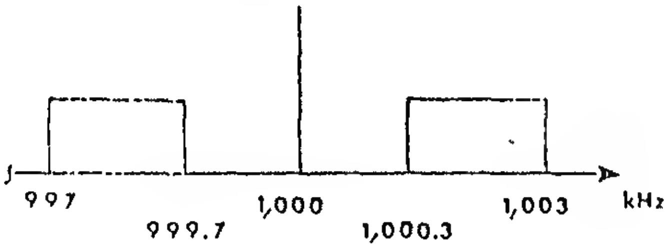
a. 1,000 kHz (r-f carrier),

b. 300 Hz to 3 kHz (audio-modulation frequency),

c. 1,000.3 kHz to 1,003 kHz (upper sideband),

d. 997 kHz to 999.7 kHz (lower sideband).

These frequencies will appear on the frequency spectrum as shown below.



The audio is lost as a discrete frequency, and the carrier and the two sidebands are transmitted.

Assume that a 5,500-kHz carrier is modulated by a band of audio frequencies of 300 Hz to 3 kHz. The frequencies that are transmitted are

______________________, ______________________,

and ______________________.

_____ (4) Modulation envelope.

Definitions

a. The process of combining an audio-modulatin signal with an r-f carrier frequency, which produces a waveshape whose amplitude varies according to the amplitude of the modulatin signal.

b. The outline of an amplitude-modulated wave

c. The ratio of the peak amplitude of the modulating signal to the peak amplitude of the r-f carrier, expressed as a percentage

d. The combining of two frequencies across a nonlinear component, which results in the sum, the difference, and the two original frequencies.

---

(1) d.

(2) a.

(3) c.

(4) b.

5. The band of frequencies on either side of the carrier is called a SIDEBAND. The UPPER sideb is the band of frequencies created by the carr PLUS the modulating frequencies. The LOWER si is the band of frequencies created by the carr MINUS the modulating frequencies.

The upper sideband is created by the carrier

_____________ the modulating frequencies.
(plus/minus)

quencies of 400 Hz to 4 kHz. What frequencies a

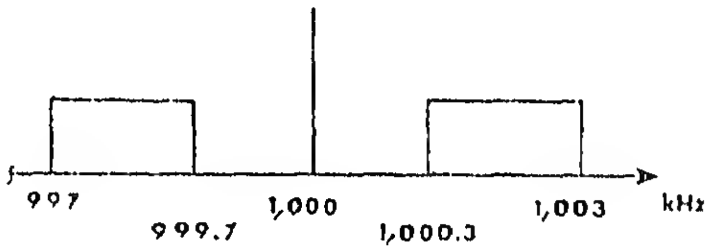
transmitted?

kHz.

to
6 kHz.

4 to
kHz.

7. The frequency spectrum indicated in the figure below represents a 1,000-kHz carrier modulated by audio frequencies of 300 Hz to 3 kHz.



This spectrum is transmitted by an a-m transmitte and the intelligence is contained in the sideband The a-m receiver must be designed to receive this signal.

As shown in the figure above, in order to receive the 1,000-kHz transmission and obtain the intelli gence, the receiver must have a 6-kHz bandwidth c

modulating frequency is 3 kHz; therefore, 2 x 3
equals 6 kHz, the necessary bandwidth. This met
applies only to a-m receivers.

What is the bandwidth of an a-m receiver designe
to receive an a-m transmission of 5,500 kHz
modulated by audio frequencies of 500 Hz to 5 kH

---

10 kHz.

8. Select the definition of *upper sideband*.

   a. The band of frequencies created by the carrier minus the modulating frequencies.

   b. The band of frequencies created by the carrier plus the modulating frequencies.

   c. The band of frequencies used for modulation.

---

b.

9. Assume that an a-m transmitter is transmitting a
9,000-kHz r-f carrier that is modulated by audic
frequencies of 300 Hz to 3 kHz. What frequencie
are transmitted?

_____ (1) Modulation envelope.

_____ (2) Amplitude modulation.

_____ (3) Modulating (heterodyning).

_____ (4) Percentage of modulation.

Definitions

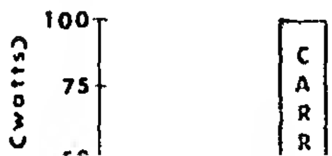
a. The combining of two frequencies across a nonlinear component, which results in the sum, the difference, and the two original frequencies.

b. The ratio of the peak amplitude of the modulating signal to the peak amplitude of the r-f carrier, expressed as a percentage.

c. The outline of an amplitude-modulated wave.

d. The process of combining an audio-modulating signal with an r-f carrier frequency, which produces a waveshape whose amplitude varies according to the amplitude of the modulating signal.

11. When a carrier is modulated 100 percent by an audio signal, the sidebands contain one-third of the TOTAL average transmitted power (one-sixth in each sideband), as indicated in the figure below.



	is contained in the sidebands. In other words, carrier contains two-thirds of the total averag transmitted power, and the sidebands contain on third of the total average transmitted power. An a-m transmitter transmits a total average po of 750 watts and is modulated 100 percent. The power contained in the carrier is ____________ watts and in the sidebands ____________ wa
500 250	12. Compute the receiver bandwidth necessary to rec an a-m transmission of 4,800 kHz modulated by a frequencies of 400 Hz to 4 kHz. a. 4 kHz. b. 6 kHz. c. 8 kHz. d. 16 kHz.
c.	13. Compute the frequencies transmitted from an a-m transmitter when a 7,500-kHz r-f carrier is modulated by audio frequencies of 300 Hz to 3 k

HIGH-LEVEL modulation. If the modulating signal is applied at a point where the power is low compared to the output power of the system, it is termed LOW-LEVEL modulation.

When low-level modulation is used, at least two factors must be considered.

(1) The frequency of the modulated signal cannot be multiplied, or the sideband frequencies will also be multiplied, resulting in distortion.

(2) All amplification stages following the modulating stage must operate linearly to prevent distortion.

a. High-level modulation occurs when the modulating signal is applied at a point where the power level approximates the ________ ____________ of the system.

b. Low-level modulation occurs when the modulating signal is applied at a point of ________ ____________ compared to the final output power.

a. 400 watts in the carrier and 200 watts in the sidebands.

b. 300 watts in the carrier and 300 watts in the sidebands.

c. 200 watts in the carrier and 400 watts in the sidebands.

d. 100 watts in the carrier and 500 watts in the sidebands.

---

a.

16. What is the required bandwidth of an a-m rece designed to receive a 9,100-kHz carrier modu by audio frequencies of 500 Hz to 5 kHz?

---

10 kHz.

17. Select the definition of *upper sideband*.

a. The band of frequencies used for modulation.

b. The band of frequencies created by the carrier minus the modulating frequencies.

c. The band of frequencies created by the carrier plus the modulating frequencies.

b. When the modulating signal is applied at a point where the power level approximates the power output of the system.

c. When the modulating signal is applied at a point of low power compared with the power output of the final stage.

d. When the modulating signal is of the same amplitude as the r-f carrier.

e. When the modulating signal is of a greater amplitude than the r-f carrier.

---

19. If an a-m transmitter transmits a total average power of 75 watts and is modulated 100 percent, what is the power contained in (a) the carrier and (b) both sidebands?

a. Carrier: ______________________.

b. Sidebands: ____________________.

21. An a-m transmitter is modulated 100 percent and transmits a total average power of 150 watts. How much of this power is contained in (a) the carrier and (b) the sidebands?

a. Carrier: ______________________.

b. Sidebands: ______________________.

watts

atts

22. Select the definition of *high-level modulation*.

a. The modulating signal is applied before the final stage.

b. The modulating signal is of a higher amplitude than the r-f carrier.

c. The modulating signal is applied at a

c. The modulating signal is of a lower amplitude than the r-f carrier.

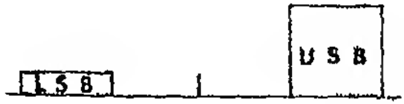
24. Single-sideband transmission is a method of transmitting whereby the carrier and one sideband of an a-m signal are suppressed and only one sideband is transmitted. It does not matter which sideband is transmitted.

In the type of transmission termed "single-sideband transmission," the carrier and one sideband of an a-m signal are ______________________ and the other sideband is ______________________.

25. There are several types of single-sideband transmissions. Each has its own particular advantages and disadvantages in different situations. The four types generally used today are as follows:

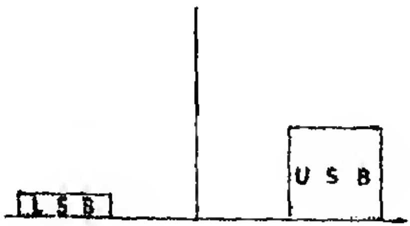
(1) Single-sideband suppressed-carrier (SSSC).--The carrier and one sideband are suppressed approximately 30 to 50

purposes. To receive SSSC, the receiver must reinsert the carrier so that it can have a reference for demodulation.



S S S C

(2) Amplitude-modulation equivalent (AME).--The carrier and one sideband are suppressed. Then the carrier is reinserted at maximum strength. The carrier and one sideband are transmitted.



A M E

(3) Pilot carrier (exalted carrier).--The carrier and one sideband are suppressed, and then the carrier is reinserted at about 10 to 20 decibels (10 to 100 times) below the peak transmitter power. The

sideband and reinserted for demodulation.

PILOT

(4) Vestigial sideband.--The carrier and one sideband are only partially suppressed. This type of transmission is used primarily in TV.

VESTIGIAL

List the four types of single-sideband transmissions.

(1)

(2)

(3)

(4)

modulation
equivalent
(AME).

Pilot
carrier.

Vestigial
sideband.

bands of equal amplitude are trans-
mitted.

b. A method of transmission whereby both sidebands of an a-m signal are suppressed and the carrier is transmitted.

c. A method of transmission whereby the carrier and one sideband of an a-m signal are suppressed and the other sideband is transmitted.

---

c.

27. Single-sideband communications have four ad

over conventional a-m communications.

(1) One advantage is SPECTRUM CONSERVATION. An ssb signal takes up less space on the frequency band.

(2) Another advantage is POWER EFFICIENCY. For the same coverage, an ssb transmitter requires a peak power rating much less than that required of an a-m system.

(3) MINIMUM SELECTIVE FADING is obtained by using ssb, because of the absence of the carrier and the undesired sideband. This results in less distortion at the receiver.

(4) An IMPROVED SIGNAL-TO-NOISE RATIO is the result of a narrower receiver bandwidth.

(1)

(2)

(3)

(4)

Spectrum conservation.

Power efficiency.

Minimum selective fading.

Improved signal-to-noise ratio.

28. Which of the following lists four types of sideband transmissions.

a. SSSC, AME, C-W, and F-M.

b. Vestigial sideband, pilot carrier, AME, and SSSC.

c. Pilot carrier, AME, SSSC, and F-M.

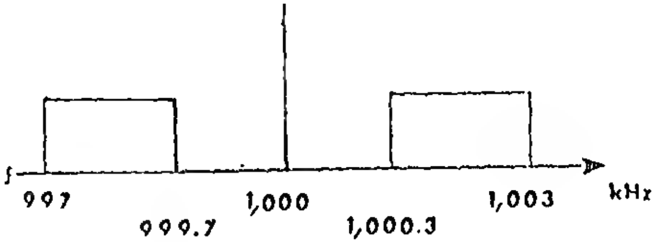
d. AME, SSSC, C-W, and vestigial sideband

---

b.

29. The advantage of SPECTRUM CONSERVATION ca easily understood by comparing an a-m sig ssb signal.

It was determined that the frequency spect



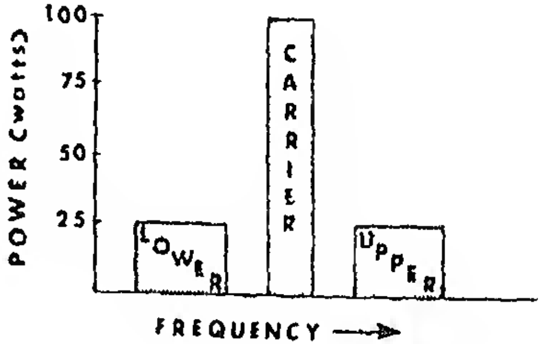
If the carrier and one sideband are suppressed a
only one sideband (either the upper or lower) is
transmitted, the receiver bandwidth now only nee
to be 2.7 kHz, or the width of the sideband tra
mitted. This is less than half of the bandwidt
requirements of an a-m receiver; thus, there ca
be two ssb channels in the same frequency range
the spectrum, where there can be only one a-m
channel.

Compute the bandwidth necessary for a receiver
receive a 5,000-kHz transmission modulated by a
frequencies of 400 Hz to 5 kHz. Compute for bo
a-m transmission and ssb transmission.

a. Bandwidth for an a-m receiver: k

	b. Spectrum conservation, improved signal- to-noise ratio, minimum selective fadi and power efficiency. c. Minimum selective fading, power effici shorter range, and spectrum conservati d. Easier maintenance, power efficiency, less cost, and improved signal-to-nois ratio.
b.	31. List three types of single-sideband transm (1) (2) (3)
SSSC. AME. Pilot carrier. Vestigial sideband. (Any three.)	32. Select the definition of *single-sideband t* *mission*. a. A method of transmission whereby both sidebands of an a-m signal are suppres and the carrier is transmitted. b. A method of transmission whereby the carrier is suppressed and two sideband of equal amplitude are transmitted. c. A method of transmission whereby the carrier and one sideband of an a-m signal are suppressed and only one sideband is transmitted.

100 percent by an audio signal, the sidebands EACH contain one-sixth of the TOTAL average transmitted power.



Both sidebands are caused by the same modulating signal; both sidebands contain exactly the same intelligence; the sidebands are only mirror images of one another. Therefore, why transmit 150 watts as in the a-m spectrum above, when only 50 watts (one sideband) will deliver the same intelligence?

Under ideal conditions, a 150-watt a-m transmitter could be replaced with a 50-watt ssb transmitter with the result of less weight, smaller size, and lower power requirements for the same communications.

3 kHz?

a. 5.4 kHz.

b. 2.7 kHz.

c. 10 kHz.

d. 6 kHz.

35. List the four advantages of ssb communications
a-m communications.

(1)

(2)

(3)

(4)

er
iciency.

ctrum
servation.

imum
ective
ing.

36. List three types of single-sideband transmissi

(1)

(2)

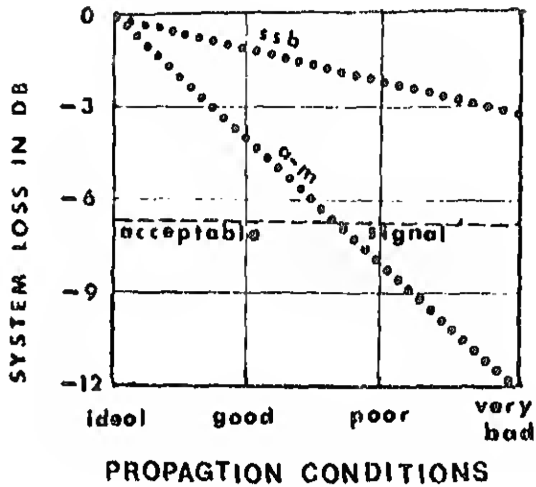
(3)

sideband. (Any three.)	in the ionosphere. If the ionosphere is unifor there is no sideband shift. *Selective fading* is defined as a distortion of the received signal, caused by a ___________ in relationship between the ___________ the ___________.
change sideband(s) carrier	38. What receiver bandwidth is necessary to receive an ssb transmission of 7,000 kHz modulated by audio frequencies of 300 Hz to 3 kHz?
2.7 kHz.	39. List four advantages of single-sideband communi tions as compared with a-m communications. (1) (2) (3) (4)

Minimum selective fading. Improved signal-to-noise ratio.	condition of the ionosphere. State why selective fading is held to a mini when using ssb systems.
Only one sideband is transmitted, and there is no carrier.	41. Select the definition of *selective fading*. a. Fading of the received signal, caused by movement of the transmitter while trans-mitting. b. Distortion of the received signal, cause by a change in relationship between the sideband(s) and the carrier. c. Distortion caused by improper tuning of the transmitter. d. Fading of a received signal, caused by jamming by another transmitter operatin on the same frequency.
b.	42. Compute the receiver bandwidth necessary to receive an ssb transmission of 4,100 kHz mo by audio frequencies of 400 Hz to 4 kHz.

Study the chart while interpreting the statements below.

This chart is shown in decibel signal-power loss. It compares the ssb signal to the a-m signal as propagation conditions continue to grow worse. The total sideband power is the same in both transmitters.



a. Under ideal conditions (0-decibel loss), the two systems are about equal.

b. At -6 decibels, the a-m signal is just barely usable, but the ssb signal is still good.

c. As propagation conditions become increasingly worse, the ssb signal is still above the acceptable level, but the a-m signal can no longer be used.

d. Under extremely bad conditions (severe fading and interference), there is a 9-decibel signal-to-noise ratio advantage of the ssb system over an equivalent a-m system.

The reason for an improved signal-to-noise ratio in ssb communications systems over a-m communications systems is the

b. only one sideband is transmitted, and there is no carrier.

c. single-sideband requires a larger antenna and puts out more power, so the signal is affected less.

d. ssb is only used on days when the ionosphere is even.

45. The reason for the improved signal-to-noise ratio in ssb communications over a-m communications is that

a. more power is used in the ssb signal.

b. the ssb receiver has a narrower bandwidth requirement than the a-m receiver.

c. ssb receivers are more sensitive than a-m receivers.

d. an ssb signal has a wider bandwidth than an a-m signal.

46. Select the definition of *selective fading*.

a. Fading of a received signal, caused by jamming by another transmitter operating on the same frequency.

b. Fading of the received signal, caused by movement of the transmitter while transmitting.

c. Distortion caused by improper tuning of the transmitter.

Only one sideband is transmitted, and there is no carrier.	48. State the reason for the improved signal-to-n ratio in single-sideband communications as co to a-m communications.
Because the ssb signal has a narrower bandwidth than the a-m signal.	You have completed this program. Review the objectives on pages i and ii. If you do not completely understand an objective, turn to the frame/s indicated by the number/s in parentheses.

REFERENCES:

1. *Fundamentals of Single-Sideband.* NAVSHIP 93271. Chapters 1-4.

2. *Single-Sideband Communications.* NAVSHIPS 93224.

1. Select the definition of each of the terms below. (10)

_____ (1) Modulating (heterodyning).

_____ (2) Amplitude modulation.

_____ (3) Percentage of modulation.

_____ (4) Modulation envelope.

Definitions

a. The ratio of the peak amplitude of the modulating signal to the peak amplitude of the r-f carrier, expressed as a percentage.

b. The process of combining an audio-modulating signal with an r-f carrier frequency, which produces a waveshape whose amplitude varies according to the amplitude of the modulating signal.

c. The outline of an amplitude-modulated wave.

d. The combining of two frequencies across a nonlinear component which results in the sum, the difference, and the two original frequencies.

2. Compute the frequencies transmitted from an a-m transmitter wh a 9,500-kHz carrier is modulated with audio frequencies of 300 to 3 kHz. (13)

c. The band of frequencies used for modulation.

. Compute the receiver bandwidth necessary to receive an a-m transmission of 4,400 kHz modulated by audio frequencies of 300 Hz to 3 kHz. (20)

. A particular a-m transmitter is modulated 100 percent and transmits a total average power of 300 watts. How much of this power is contained in (a) the carrier and (b) the sidebands? (21)

a. Carrier: ______________________________.

c. The modulating signal is of a higher amplitude than the r-f carrier.

7. Select the definition of *low-level modulation*. (23)

a. The modulating signal is of a lower amplitude than the r-f carrier.

b. The modulating signal is applied at a point of low power compared to the power output of the final stage.

c. The modulating signal is applied at a point of high power compared to the power output of the final stage.

8. Select the definition of *single-sideband transmission*. (32)

a. A method of transmission whereby the carrier is suppressed and two sidebands of equal amplitude are transmitted.

b. A method of transmission whereby the carrier and one sideband of an a-m signal are suppressed and only one sideband is transmitted.

c. A method of transmission whereby both sidebands of an a-m signal are suppressed and the carrier is transmitted.

9. List three types of single-sideband transmissions. (36)

(1)

(2)

(3)

(3)

(4)

11. Compute the receiver bandwidth necessary to receive an ssb tra
mission of 9,000 kHz modulated by audio frequencies of 200 Hz to 5 kHz. (42)

12. Select the definition of *selective fading.* (46)

    a. Fading of the received signal, caused by movement of the transmitter while transmitting.

    b. Distortion of the received signal, caused by a change in relationship between the sideband(s) and the carrier.

    c. Distortion caused by improper tuning of the transmitter.

    d. Fading of a received signal, caused by jamming by another transmitter operating on the same frequency.

13. Why is selective fading held to a minimum when using single-si
band communications? (47)

The student will:

1. List three major disadvantages of single-sideband communications. (1)

2. State the required accuracy for a stabilized master oscillator in a single-sideband system. (2)

3. State how frequency-stability requirements increase complexity and cost of single-sideband circuitry. (4)

4. State the type of amplifier used after the modulation stage in a single-sideband transmitter. (7)

5. State the classes of operation used in amplifiers following the modulation stage in a single-sideband transmitter. (10)

6. State the most frequently used method for carrier suppression in a single-sideband transmitter. (14)

7. State the output of the balanced modulator when used in a single-sideband transmitter. (14)

8. List the two methods of sideband selection in a single-sideband transmitter. (17)

9. State the most frequently used method of sideband selection in a single-sideband transmitter. (17)

10. State the output of a sideband filter when used in a single-sideband transmitter. (17)

11. State what must be added to the received signal before it can be demodulated in an ssb receiver. (31)

12. Label the last three stages of a basic single-sideband receiver. (32)

13. State the two requirements of the avc used in single-sideband receivers. (34)

e number listed after each objective refers
 the first frame teaching that objective.

SUGGESTED READING TIME 56 MINUTES

statement. As impressive as ssb communication

appear, there are three major disadvantages:

(1) FREQUENCY STABILITY.--The total frequency shift in the system, both transmitting and receiving, *should not exceed 50 Hz*.

(2) COMPLEX CIRCUITS.--The circuits required to accomplish the frequency stability must be of precision design.

(3) LINEAR AMPLIFICATION.--When a transmitter is modulated low-level, the amplifiers after the modulation stage must be operated linearly.

List the three major disadvantages of ssb comm

cations.

(1)

(2)

(3)

---

requency- tabililty equirements.

omplex-circuit equirements.

2. A major requirement of ssb is FREQUENCY STABI

An error greater than 50 Hz will cause the in

gence (modulation) to be degraded or distorte

accomplish this accuracy, special circuits are required for the oscillators: ovens are used to control temperature and humidity; and corrective circuits, to correct any drift in frequency. These special circuits are the major cost of ssb equipment.

The accuracy of a STABILIZED MASTER OSCILLATOR (SMO) in an ssb system must be within ________________ percent.

---

3. The three major disadvantages of ssb communications are

   a. linear amplification, frequency stability, and bulky equipment.

   b. complex-circuit requirements, linear amplification, and frequency-stability requirements.

   c. less power, complex-circuit requirements, and nonlinear amplification.

   d. difficult troubleshooting, linear amplification, and less power.

	the transmitter, suppressing the carrier and the unwanted sideband requires precision design. In the receiver, carrier insertion and demodulation require precision design. All these factors, whic contribute to the precision of the special circuit increase the complexity and cost of ssb circuitry. State how frequency-stability requirements increas complexity and cost of ssb circuitry.
ecision sign is cessary for e special rcuits.	5. What is the required accuracy of a stabilized master oscillator (SMO) in a single-sideband system?
thin 0.00001 rcent.	6. What are the three major disadvantages of ssb communications? (1) (2)

bring its power level up to that which is required for transmission. Any such amplification of the signal after the modulation stage must be done by amplifiers which do not change the sideband relationships. Obtaining the desired transmitter output-power level and reproducing the sideband relationships faithfully require LINEAR AMPLIFICATION.

A LINEAR AMPLIFIER develops an output with minimum distortion, directly proportional in amplitude to the input signal.

The type of amplifiers used after the modulation stage in an ssb transmitter is ______________.

8. How do the frequency-stability requirements increase complexity and cost of ssb circuitry?

   a. The weight factor is responsible for ssb equipment's costing more than a-m equipment.

   b. Precision design is necessary for the special circuits.

   c. The tremedous power requirements of ssb make the power supplied more expensive.

(3)

equency-
ability
quirements.

nplex-
rcuit
quirements.

near
plification.

10. Class A amplification is noted for its linearity
However, class A amplifiers have low efficiency
and, therefore, they are not suitable for use as
ssb power amplifiers. The power obtained from
class C amplification is desirable, but this typ
is noted for its high distortion (poor linearity
As a compromise between efficiency and linearity
the linear amplifiers of an ssb system are opera
by class AB or class B (push-pull). By using th
classes, the linearity is retained, and suffici
power is acquired.

a. Because of high distortion, linear amplifie
in an ssb system are *not* operated class ____
even though this class gives good efficienc

b. Because of poor efficiency, linear amplifie
are *not* operated class ____, even though th
class has the best linearity.

c. The linear amplifiers of an ssb system are
operated class ____ or class ____.

ull)

b. magnetic amplifier.

c. linear amplifier.

d. colinear amplifier.

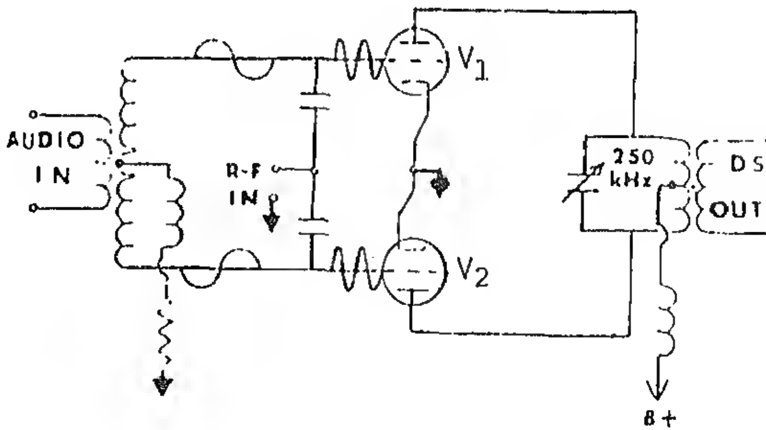
12. State how frequency-stability requirements increase complexity and cost of ssb circuitry.

for
l

13. What is the required accuracy of a stabilized master oscillator (SMO) in a single-sideband system?

transmitter to suppress the carrier and to sele the sideband that is to be transmitted. In the receiver, circuits are needed to reinsert the carrier. These are the major differences. Oth wise, the circuits required for a-m and ssb are identical.

Some of these special circuits are shown on thi and the following pages. Within the ssb transm it is desirable to suppress the carrier without interfering with the sidebands. This is the pu of the BALANCED MODULATOR, shown below.



When an r-f carrier alone is applied to both gr

cancel each other.

When audio alone is applied push-pull (positive on one grid and negative on the other), the tubes conduct alternately and produce an output. But the plate-tank circuit is tuned to 250 kHz, not audio; therefore, the audio signal is not developed, because of the minimum impedance of the plate-tank circuit.

When the r-f and audio are applied at the same time, the original r-f and audio frequencies do not appear in the output because of the action of the plate-tank circuit, as explained above. The sum and difference frequencies, which are the upper and lower sidebands, will appear in the output. What has occurred is that the r-f carrier has been modulated and suppressed, leaving a double-sideband output.

a. The most frequently used method of carrier suppression in an ssb transmitter is the use of ______________________________.

b. The output of the balanced modulator in

carrier

b. class B or class C.

c. class AB or class B (push-pull).

d. class C or class A.

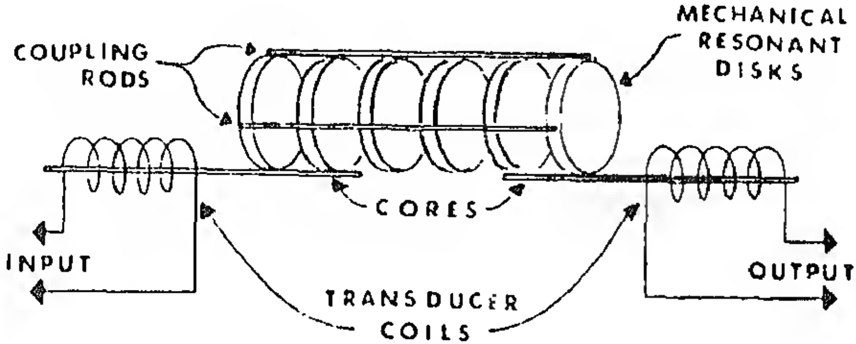
16. How do frequency-stability requirements increase complexity and cost of single-sideband circuitry?

ecision sign is cessary for e special rcuits.

17. After the balanced modulator has suppressed the carrier and produced a double-sideband output, the desired sideband to be transmitted must be selected. This can be done by one of two methods: (1) PHASE-SHIFT method or (2) FILTER method. The phase-shift method is seldom used and will not be discussed in this lesson.

The second method, and the one most frequently used

cal filter shown below.



A magnetic field is produced when an electrical signal applied to the input terminals sends a current through the transducer coil. This magnetic field acts on the core and causes it to vibrate at the operating frequency. This mechanical energy drives the metal disks, which mechanically vibrate or resonate. The motion, mechanically coupled to the output transducer, induces a voltage in the output coil. Thus, the mechanical energy is changed back into electrical energy. The mechanical filter is highly selective and will pass only the frequencies in the range for which it is constructed. In a single-sideband transmitter, the output of the

sideband, and only that sideband will be passed. In ssb transmitters, where either sideband can be transmitted, two mechanical filters will be available: one tuned to the upper sideband and one tuned to the lower sideband. By selecting the proper mechanical filter, either sideband may be transmitted.

a. List the two methods of sideband selection in an ssb transmitter.

(1)

(2)

b. Which of the methods above is most frequently used?

c. In a single-sideband transmitter, what is the output of the sideband filter?

c. i-f amplifier.

d. | d. carrier suppressor.

19. The output from a balanced modulator in an ssb transmitter is a

a. single-sideband output.

b. double-sideband output with no carrier.

c. double-sideband output with the carrier.

d. carrier with no sidebands.

20. What type of amplifier is used after the modulation stage in an ssb transmitter?

21. The two methods of sideband selection used in an ssb transmitter are the

a. balanced-modulator method and the phase-shift method.

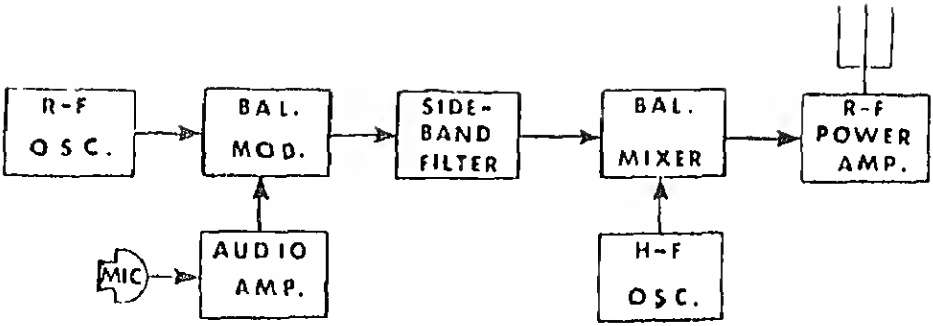
b. phase-shift method and the filter method.

c. filter method and the buffer-multiplier method.

d. tuned-tank method and the phase-shift method.

	b. balanced-modulator method. c. filter method. d. tuned-tank method.
c.	23. The output of a sideband filter is a. the undesired sideband. b. the carrier. c. both sidebands. d. one sideband.
d.	24. What classes of operation are used in the amplifiers following the modulation stage i ssb transmitter?
Classes AB and .B (push-pull).	25. What is the most frequently used method of suppression in an ssb transmitter?

vith :.	27. List the two methods of sideband selection in an ssb transmitter. (1) (2)
ft thod.	28. Which method of sideband selection is the most frequently used method in an ssb transmitter?
thod.	29. State the output of the sideband filter when used in an ssb transmitter.



a. The r-f oscillator generates the r-f carrier, which is applied to the balanced modulator.

b. The audio amplifier amplifies the intelligence to an acceptable level and delivers it to the balanced modulator.

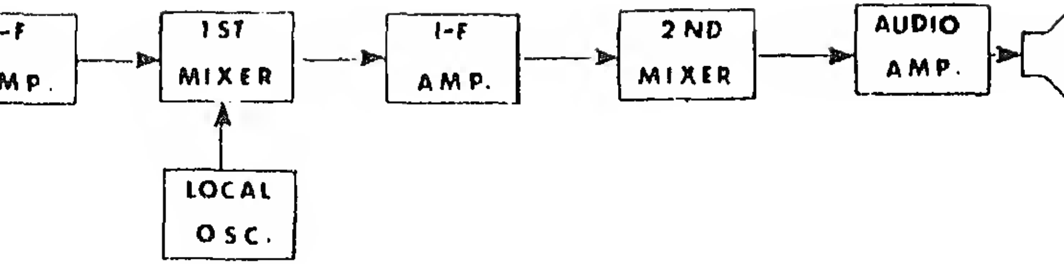
c. At the output of the balanced modulator, the double sideband (no carrier) is applied to the sideband filter.

d. The sideband filter rejects one sideband and passes the other (the desired one) to the balanced mixer.

e. At the balanced mixer, the sideband is stepped up to the desired frequency for transmission by heterodyning it with the signal from the high-frequency (h-f) oscillator. The output of the balanced mixer is tuned to the sum (transmitter) frequency.

f. This signal is then amplified by linear r-f power amplifier(s) and is transmitted.

g. The transmitter above represents the SSSC type of transmission. SSSC is the most frequently



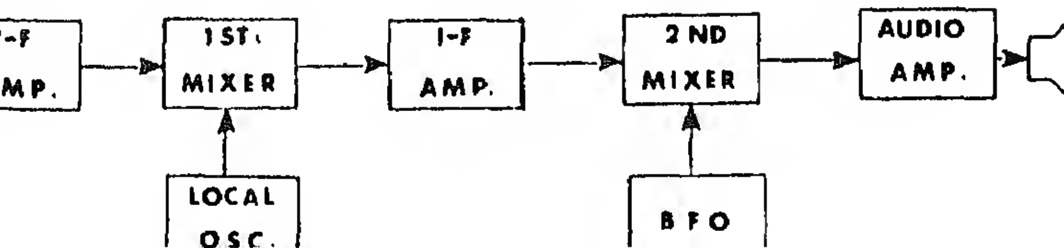
a. The r-f amplifier is used to amplify the incoming r-f signal.

b. The local oscillator and the first mixer are used to lower the r-f frequency to the intermediate frequency (i-f).

c. The i-f amplifier is used to amplify the i-f signal.

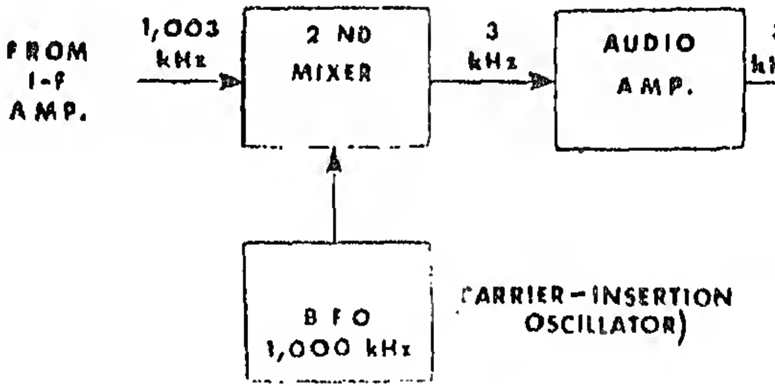
d. The second detector demodulates the i-f signal and obtains the received intelligence. At this point, the ssb receiver differs from the a-m receiver. At this point, an ssb receiver must insert a carrier to obtain the sideband intelligence.

This is done by replacing the a-m second detector with a carrier-beat-frequency oscillator (bfo) and a second mixer. The block diagram of an ssb receiver is shown below.



The carrier.

32. In order to recover the intelligence from th
signal, it is necessary first to restore the
carrier. This local carrier must have the s
relationship with the ssb components as the
carrier used in the modulator of the transmi

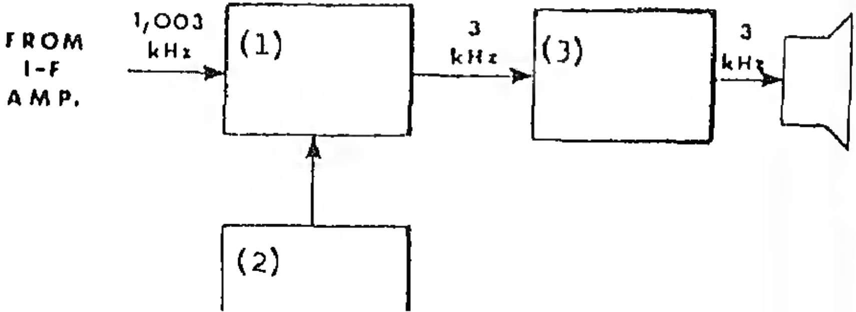


As shown above, the i-f, which in this case
frequency of 1,003 kHz (one sideband), is th
frequency present at the input to the second
The *carrier* is absent. The carrier was supp
in the transmitter after it had been heterod
with the audio to produce the modulated r-f

frequency oscillator (bfo). The bfo is a variable-frequency oscillator. It must be tuned exactly to the original carrier frequency to prevent the output intelligence from being distorted.

The bfo signal is combined with the output of the i-f amplifier in the second-mixer stage. Thus, the second mixer converts the i-f frequency to an audio frequency by heterodyning the sideband with the bfo frequency. This audio is coupled to the final stage. The final stage is an audio amplifier, which amplifies the audio to a level necessary for the operation of a loudspeaker or headset.

Label the last three stages of the ssb receiver below.



b. The carrier.

c. The audio.

d. Strength.

b.

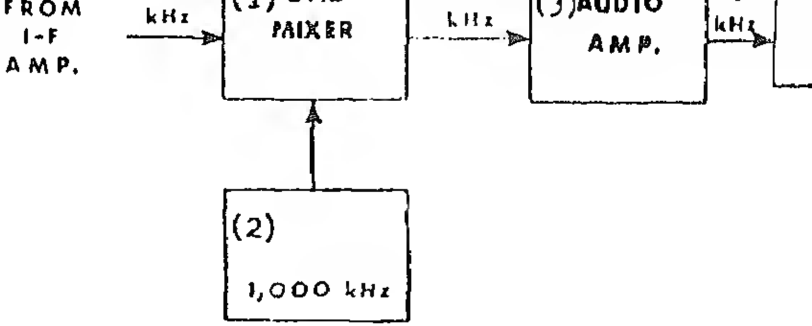
34. Another feature, or requirement, of an ssb re
that differs from those of its a-m counterpar
the automatic volume control (avc) that must
used. A single-sideband suppressed-carrier (
signal has no continuous carrier to provide a
for avc, as does an a-m signal; therefore, co
tional avc circuits are unsatisfactory. The
for ssb should develop instantly during the f
syllable of each strong signal and should dec
slowly to prevent "hissing" at the end of the
syllable. These two requirements are met by
type of avc called *fast-charge, slow-discharg*
This avc uses several RC networks to apply th
voltage to various sections of the receiver.
the absence of the carrier (as in SSSC), the
circuit remains effective because of the long
constants used.

State the type of avc used in ssb communicati
and the two necessary requirements that must
met.

a. Type: ____________________.

b. Requirements:

ecay
owly.



BFO

36. Utilizing ssb techniques, it is possible to plac two voice signals on the air with one transmitte one on the upper sideband and one on the lower sideband. To operate multichannel, the transmit would require two complete and separate sideband generators. This would include the audio amplifiers, balanced modulators, and sideband filters although the generators are separate, the same oscillator stages may be used.

What is the major requirement of a multichannel transmitter?

c. Automatically control the volume and prevent static.

d. Increase receiver sensitivity and prevent hissing.

38. What type of avc is used in ssb communications?

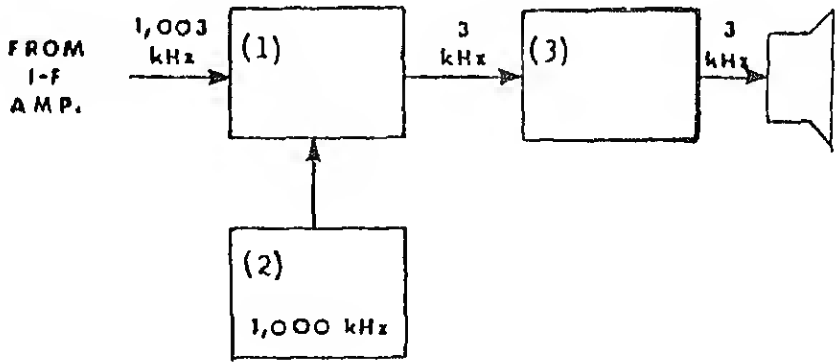
a. Conventional avc.

b. "Quick" avc.

c. Fast-charge, slow-discharge avc.

d. No avc is used.

39. Complete the block diagram below for the last three stages of an ssb receiver.



er.

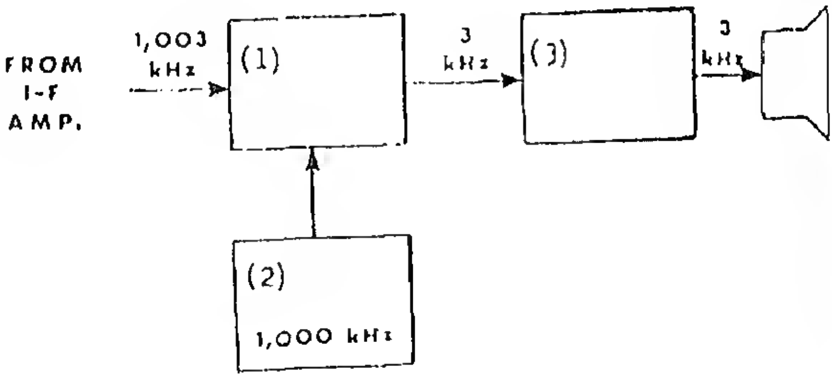
41. The major requirement of a multichannel ssb transmitter is

a. separate sideband generators for each channel.

b. separate oscillators for each channel.

c. separate power supply for each channel.

42. Label the blocks below that represent the last three stages of a basic ssb receiver.



(1)

(2)

Develop instantly. Decay slowly.	44. What type of avc is used in ssb communicatio
Fast-charge, slow-discharge.	45. What is the major requirement of a multichan ssb transmitter?

You have completed this program. Review the objectives on pages 34 and 35. If you do not understand an objective, turn to the frame indicated by the number in parentheses.

REFERENCES:

1. *Fundamentals of Single-Sideband.* NAVSHIPS 93271. Chapters 1-4.

2. *Single-Sideband Communications.* NAVSHIPS 93224.

1. List three major disadvantages of single-sideband communications. (9)

   (1)

   (2)

   (3)

2. What is the required accuracy for a stabilized master oscillator in a single-sideband system? (13)

3. How do frequency stability requirements increase complexity and cost of single-sideband circuitry? (16)

4. What type of amplifier is used after the modulation stage in a single-sideband transmitter? (20)

5. What classes of operation are used in the amplifiers following the modulation stage in a single-sideband transmitter? (24)

6. What is the most frequently used method of carrier suppression in a single-sideband transmitter? (25)

transmitter. (27)

(1)

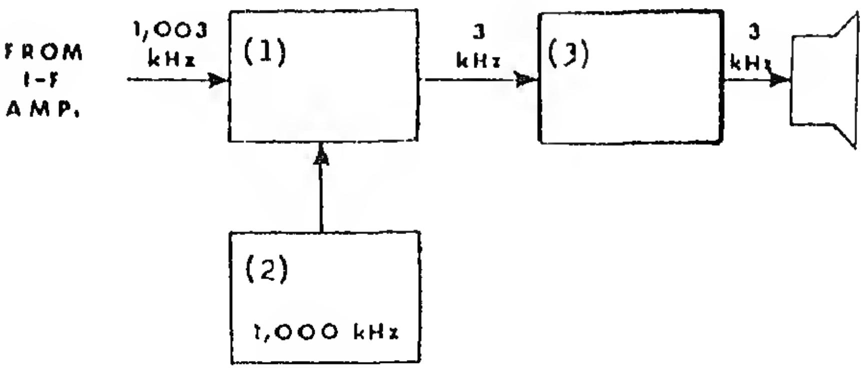
(2)

Which method of sideband selection is the most frequently used? (28)

State the output of the sideband filter when used in a single-sideband transmitter. (29)

What must be added to the received signal before it can be demodulated in a single-sideband receiver? (40)

Label the blocks below that represent the last three stages of a basic single-sideband receiver. (42)



14. What type of avc is used in single-sideband communications?

15. What is the major requirement of a multichannel single-sideb
transmitter? (45)

GUARDIAN OF OUR COUNTRY

The United States Navy is responsible for maintaining control of the sea and is a ready force on watch at home and overseas, capable of strong action to preserve the peace or of instant offensive action to win in war.

It is upon the maintenance of this control that our country's glorious future depends. the United States Navy exists to make it so.

WE SERVE WITH HONOR

Tradition, valor, and victory are the Navy's heritage from the past. To these may be added dedication, discipline, and vigilance as the watchwords of the present and the future

At home or on distant stations we serve with pride, confident in the respect of our country, our shipmates, and our families..

Our responsibilities sober us; our adversities strengthen us.

Service to God and Country is our special privilege. We serve with honor.

THE FUTURE OF THE NAVY

The Navy will always employ new weapons, new techniques, and greater power to protect and defend the United States on the sea, under the sea, and in the air.

Now and in the future, control of the sea gives the United States her greatest advantage for the maintenance of peace and for victory in war.

Mobility, surprise, dispersal, and offensive power are the keynotes of the new Navy. The roots of the Navy lie in a strong belief in the future, in continued dedication to our tasks, and in reflection on our heritage from the past.

Never have our opportunities and our responsibilities been greater.